FFI Norwegian Defence Research Establishment

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FFI-REPORT

CBRNE Accident Coordination Training (CBRNE-ACT) System

– technical description

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Summary

The use of computer simulation and virtual environments allow for cost-effective education, training, and exercises. The training audience can be exposed to scenarios that are inaccessible or too dangerous, too complex, or too expensive to recreate in a live environment. The use of virtual training environments is therefore widespread within the defence community. CBRNE (Chemical, Biological, Radiological, Nuclear and Explosive) incidents pose many of the same challenges as mentioned above, making virtual environments a useful tool for both CBRNE incident training and education.

This document describes the CBRNE Accident Coordination Training demonstrator (CBRNE-ACT) that has been developed by the Norwegian Defence Research Establishment (FFI). It also describes the user needs and requirements, design, and implementation of CBRNE-ACT.

FFI has previously developed a demonstrator to show possibilities for training on response and management of CBRNE incidents. This demonstrator uses NATO and civilian standards and consists of military commercial off-the-shelf computer-generated forces and simulation components to include dispersion of a toxic gas and its effect on personnel.

The goals of the Norwegian contribution to the CBRNE project were to adapt and further develop the FFI CBRNE demonstrator for a specific training scenario, to import high-fidelity dispersion data, and to perform an experiment with (end) users.

Our work has been performed in cooperation with the Norwegian Civil Defence and supporting the civil defence course *Interaction at a contaminated incident site CBRN/E*. This is a tactical management course that introduces the challenges associated with handling a CBRNE incident. The course gives a comprehensive and up-to-date competence in handling such an incident. The interaction between the actors involved may be enhanced through joint training of emergency personnel who will be involved when such an incident occurs. It is essential that the course provides the necessary skillset to carry out operational and tactical assessments and to interact with other agencies and organizations.

FFI has used a standard process for the development of distributed simulation system when developing CBRNE-ACT – the Distributed Simulation Engineering and Execution Process (DSEEP). This document outline is in accordance with the DSEEP steps.

CBRNE-ACT is a component-based system where the components communicate using international and NATO standards. This allows for easy extension of the system and reuse of components. The use of the distributed simulation standard High-Level Architecture (HLA) also enables connecting CBRNE-ACT to other (military) training systems.

Sammendrag

Bruk av simulering og virtuelle miljøer gjør det mulig å drive opplæring, trening og øving på en kostnadseffektiv måte. Disse teknologiene gir dem som trenes, eksponering for scenarier som kan være utilgjengelige eller for farlige, for komplekse eller for dyre å gjenskape i et reelt miljø. Bruk av virtuelle treningsmiljøer er derfor utbredt i Forsvaret. CBRNE-hendelser (kjemiske, biologiske, radiologiske, nukleære og eksplosive hendelser) har lignende utfordringer som nevnt ovenfor, noe som gjør virtuelle miljøer til et nyttig verktøy for opplæring og utdanning for håndtering av CBRNE-hendelser.

Rapporten beskriver en CBRNE-treningssimulator (CBRNE-ACT) som er utviklet av Forsvarets forskningsinstitutt (FFI). Rapporten beskriver også brukerbehov og krav, design og implementasjon av CBRNE-ACT. Treningssimulatoren er utviklet av FFI som en del av prosjektet «Strengthening CBRNE safety and security – Coordination and Standardization». Prosjektet er finansiert av norske EØS-midler («Norway grants»).

FFI har tidligere utviklet en demonstrator for å vise mulighetene for opplæring i respons og håndtering av CBRNE-hendelser. Denne demonstratoren er basert på NATO-standarder og sivile standarder og består av militære datagenererte styrker og simuleringskomponenter for spredning av giftig gass og dens virkning på personell.

Målet med den norske deltakelsen i CBRNE-prosjektet var å tilpasse og videreutvikle FFIs CBRNE-demonstrator for et spesifikt opplæringsscenario, importere høyoppløselige spredningsdata og gjennomføre et eksperiment med (slutt)brukere. Arbeidet er utført i samarbeid med Sivilforsvarets kompetansesenter og er benyttet i kurset *Samvirke på et forurenset skadested CBRN/E*. Dette er et taktisk ledelseskurs som introduserer utfordringene knyttet til håndtering av en CBRNE-hendelse. Kurset gir en omfattende og oppdatert kompetanse i å håndtere et forurenset skadested. Én måte å styrke samspillet mellom aktørene på er å legge vekt på felles opplæring for personell fra nødetater som vil være involvert når en slik hendelse oppstår.

FFI har benyttet en standard prosess for utvikling av distribuerte simuleringssystemer under utviklingen av CBRNE-ACT – «Distributed Simulation Engineering and Execution Process» (DSEEP). Dokumentets struktur følger DSEEP-trinnene.

CBRNE-ACT er et komponentbasert system der komponentene kommuniserer ved hjelp av internasjonale standarder og NATO-standarder. Dette gjør det enkelt å utvide systemet og gjenbruke komponenter. Bruk av den distribuerte simuleringsstandarden High Level Architecture (HLA) gjør det mulig å koble CBRNE-ACT til andre (militære) treningssystemer.

Preface

The project is conducted under the auspices of the Norwegian Ministry of Justice, financed by Norwegian EEA funds ("Norway grants"). Polish-Norwegian research cooperation is in its third period of funding under the EEA, and Norway Grants and have been implemented in the period 2020–2024. One of the goals of this project is to develop innovative training platforms. Our Polish partner is the "Military University of Technology" in Warsaw (WAT).

We would like to extend our thanks to the Civil Defence at Starum for their excellent cooperation by providing us with domain knowledge, helping develop the scenario, and facilitating the exercise.

Kjeller, 02.09.24
Anders Helgeland, Ole Martin Mevassvik, Arild Skjeltorp, Cecilie Jackbo Gran, Martin Asprusten og Thomas Vik

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1 Introduction

The use of computer simulation and virtual environments allow for cost-effective education, training, and exercises. The training audience can be exposed to scenarios that are inaccessible or too dangerous, too complex, or too expensive to recreate in a live environment. The use of virtual training environments is therefore widespread within the defence community. CBRNE pose many of the same challenges as mentioned above, making virtual environments a useful tool for both CBRNE incident training and education. This document describes the CBRNE Accident Coordination Training demonstrator (CBRNE-ACT) that has been developed by FFI as part of the project "Strengthening CBRNE safety and security – Coordination and Standardization".

FFI has previously developed a demonstrator to show possibilities for training on response and management of CBRNE incidents [1, 2]. This demonstrator is based on NATO and civilian standards and consists of military Computer Generated Forces (CGF) and simulation components to include dispersion of a toxic gas and its effect on personnel. The goals of the Norwegian contribution to the Polish-Norwegian CBRNE project were to i) adapt and further develop the FFI CBRNE demonstrator for a specific training scenario, ii) to import high-fidelity dispersion data and iii) to perform an experiment using CBRNE-ACT with (end) users.

Our work has been performed in cooperation with the Norwegian Civil Defence and supporting the civil defence course *Interaction on a contaminated incident site CBRN/E.* This is a tactical management course that introduces the challenges associated with handling a CBRNE incident. The course gives a comprehensive and up-to-date competence in handling a contaminated incident site. One measure to strengthen the interaction between the actors involved is to emphasize joint training of emergency personnel who will be involved when such an incident occurs. It is essential that the course gives competence to carry out operational and tactical assessments and to interact with other agencies and organizations. The report *Simulation supported CBRNE accident coordination training* [3] describes the results using the CBRNE-ACT system in an exercise as part of the civil defence course *Interaction on a contaminated incident site CBRN/E.*

FFI has used a standard process for the development of distributed simulation system when developing CBRNE-ACT – the Distributed Simulation Engineering and Execution Process (DSEEP) [4]. This document outline is in accordance with the DSEEP steps. CBRNE-ACT complements the existing course with computer-based training in a simulated environment. It provides more realistic feedback and shows the consequences of decisions and actions related to scene management. The main users are incident commanders and first responders from police, fire brigades, health services, and civil defence. The main training objectives are communication and situational awareness training, CBRNE incident training, cooperation, and scene management and evacuation procedures training.

2 User needs

This section describes the user needs for CBRNE-ACT.

2.1 Problem statement

The cooperation between the actors is essential when handling a CBRNE incident. The civil defence course *Interaction on a contaminated incident site CBRN/E* is a tactical management course that introduces the challenges associated with handling a CBRNE incident. The course consists of a combination of lessons and exercises and includes both tabletop and live exercises. CBRNE-ACT will complement the existing course scenarios and training with computer-based training. As a training tool, computer-based training could be considered as something that falls between tabletop and live exercises, with some distinct advantages. It will provide realistic feedback to the training audience (as everything is based on simulations), it is able to show the consequences of the decisions and actions performed by the users in handling a CBRNE incident site, and it will be less cost expensive than live exercises.

Figure 2.1 shows how the different role players will interact during a training session. The trainees, incident commanders (IC) and their second in command (2IC), and the instructors will by default not interact directly with CBRNE-ACT. They will give instructions to the simulator operators that are trained to use the system, and observe the virtual environment on computer monitors or, in the initial phase, in Virtual Reality (VR) by use of a Head Mounted Display (HMD) (a VR headset).

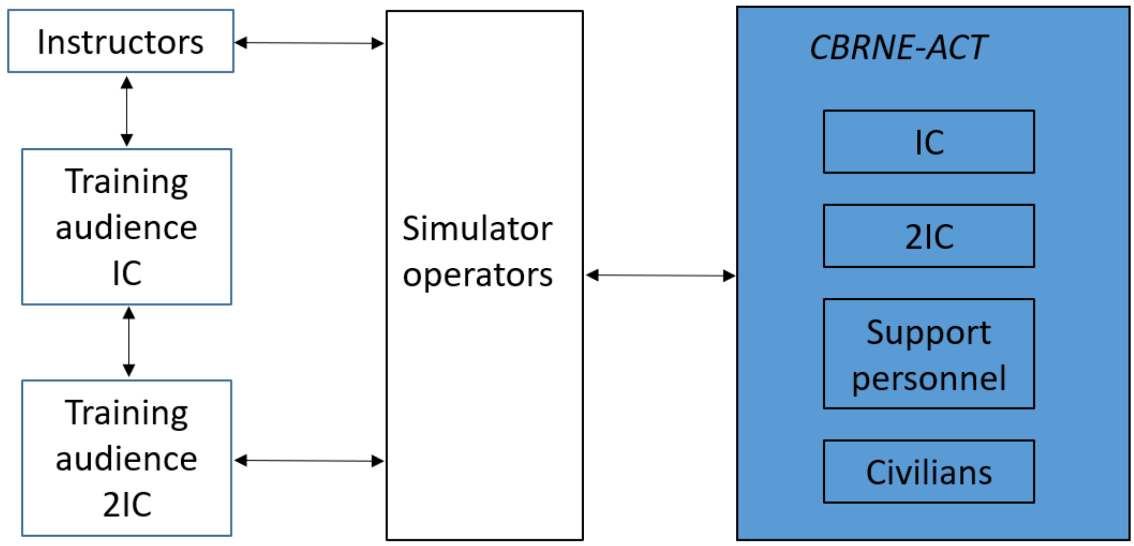


Figure 2.1 Interaction between the different role players during a training session using CBRNE-ACT.

2.2 Training audience

The training audience consists of first responders from the emergency services: police, fire brigades, and health services, and in some cases, supported by the Civil Defence as shown in figure 2.2. The main training audience in the CBRNE-ACT system is the incident commanders and their second in command.

Each service has an incident commander, whose task is to organize and lead both own personnel and coordinate with external actors during an emergency. The incident commanders should plan actions and operations in an efficient and safe manner. The second in command works closely together with the responders to execute the planned actions and operations at the incident site.

The different phases during a training session are:

- Travelling to the scene of the incident. The emergency units are separated physically, and they can only communicate using *Nødnett*[1] radios.
- Establishing a command post (CP) and organizing the incident site.
- Planning and handling the incident.

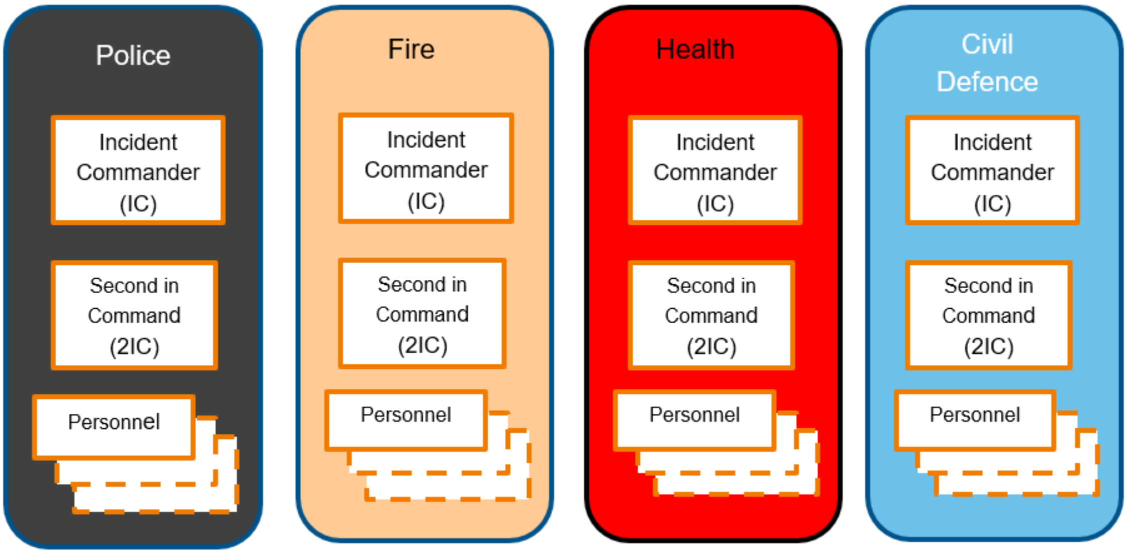


Figure 2.2 The organizations trained in the courses held by the Norwegian Civil Defence.

[1] *Nødnett* is a communication system used by all emergency services in Norway.

2.3 Training objectives

The training objectives for the CBRNE-ACT system were defined based on the existing FFI CBRNE demonstrator and on several workshops between FFI and the Norwegian Civil Defence in the planning of *Interaction on a contaminated incident site CBRN/E* held at Starum, September 2023.

The main objectives for CBRNE-ACT are to create realistic consequences of the training audience's decisions and serve as a common representation of the incident site. The proposed training objectives for the system are:

TO-1: Communication and coordination by *Nødnett* radio between the actors on the way to the incident site.

TO-2: Coordination between the actors at the incident site.

TO-3: Decision-making during the different phases of the scenario.

TO-4: Facing consequences of decisions. The system can e.g., simulate how toxic gases affect people.

TO-5: Management of resources by each emergency service.

TO-6: Prioritization of tasks by the incident commanders. E.g., where, and when to send in personnel, where to evacuate people, how to control traffic and so on.

TO-7: The first unit arriving on the scene of the incident shall deliver a first message ("vindusmelding" in Norwegian) based on observation of the scene and information provided by the instructors.

TO-8: Use the radio to read back your understanding of the first message ("vindusmelding") you received.

TO-9: Establish a Command Post (CP) at a safe location.

TO-10: Scene management, including deciding the place of attendance and different zones: Warm zone, hot zone, evacuation areas and so on.

TO-11: Brief other incident commanders as they arrive at the incident site and further through the training session.

TO-12: Manage an incident site organized into different hazard zones. Determine where emergency personnel with different types of protective equipment are allowed to operate.

TO-13: Establishing barriers to stop traffic and prevent people from moving into dangerous areas.

TO-14: Keep track of number of injured people, their extent of damage, and where they are located.

TO-15: Managing the evacuation of people located outside buildings near the incident site.

TO-16: Notification of people on site and in surrounding areas by sending text messages.

TO-17: Lessons identified and feedback based on exercise data recording.

TO-18: Optional use can be to present worst-case scenarios and best practise examples created with CBRNE-ACT.

3 Conceptual analysis

This chapter describes the scenario that is used during the first test of CBRNE-ACT. The conceptual model for the system is presented to explain the overall course of action during the training session. The scenario has been developed in cooperation with instructors from the Norwegian Civil Defence. Further, this chapter describes the user requirements for the trainee, instructor, and simulation system.

3.1 Scenario

A traffic accident occurs at the road crossing Fetveien (RV22) and Storgata, near the Kjeller airport as shown in figure 3.1. The accident involves a tank truck transporting ammonia and a container truck. Major damage to the tank causes a severe leakage of ammonia.

Several people in the area are affected by the ammonia gas. The driver of the container truck is lying down and has breathing problems. A police officer happens to be close to the scene, and from the explanation from the tank truck driver, a report of his/her perception of the incident is conveyed via radio to the emergency centre. This first message will be important for all emergency services called out to the scene of the accident.

Figure 3.1 The CBRNE incident site from the scenario. Image source is Google Earth.

3.2 Introduction to the management of the incident site

In rescue efforts where life and health are threatened, it is the police who have overall rescue management through the function Local Rescue Centre (LRS). The duty officer takes care of the management inside the police operations centre, while at the same time a local police incident manager is appointed the overall coordination of the incident. He/she will establish a command post close to the scene of the incident and will perform tactical management of the emergency crews during the operation.

The police incident commander establishes a command post together with the incident commanders from the fire brigades and health services.

Incident commanders from each emergency service lead their own crews during the incident response according to their responsibilities. Each agency communicates on its own *Nødnett* radio channel. In addition, a joint radio connection, BAPS ("Brann, Ambulanse, Politi, Samvirke" – Fire, Ambulance, Police, Cooperation) is used.

In the event of an emergency alarm, the emergency centre that receives the message must implement triple alert (notify the other centres).

On the way to the scene of the incident, all leaders of emergency units and the alarm centre is connected to the joint voice group BAPS 1, where time-critical information is conveyed. This could, for example, be information about CBRNE agents at the scene of the incident, driving route and defined place of attendance for the emergency services.

3.2.1 Conceptual model

The conceptual model in figure 3.2 explains the overall course of action for the actors participating in the training session. After an introductory brief from the training staff, the trainees get a triple alert message which leads to a call out for the emergency services, also known as the trainees. The first actor that arrive the incident site will be the ones establishing the Command Post (CP) and relay important information to the other services. Briefing of personnel arriving at the incident site is an important learning objective to obtain good interaction between the actors. Information exchange and coordination between the incident commanders are essential when planning their assignments, as well as with their second in command, to execute the assignments accurately. The instructors can do minor adjustments to the scenario during the exercise to meet the training goals and stop the scenario to provide feedback or to end the training session. In the after action review, the instructors evaluate and provide feedback to the trainees based on their observations and recording of the training session.

3.2.2 On the way to the scene of the incident

During the first phase of the training session, the emergency services receive a triple alert and move towards the scene of the incident. Some of the actors will arrive before others so this phase will overlap with the next phase considering some actors will still be on their way, while others have started their work at the incident site. Until all actors are on site, the communication between the actors is based on *Nødnett* radios on the BAPS channel. BAPS is a set of dedicated shared voice groups for the emergency services only. Every incident gets a dedicated BAPS channel. This to ensure that all actors have an updated situational awareness regardless of when they arrive, as described in figure 3.3. In addition to BAPS, the different emergency services have their own *Nødnett* channel on a separate radio device for communication with their own operations centre (110, 112 or 113).

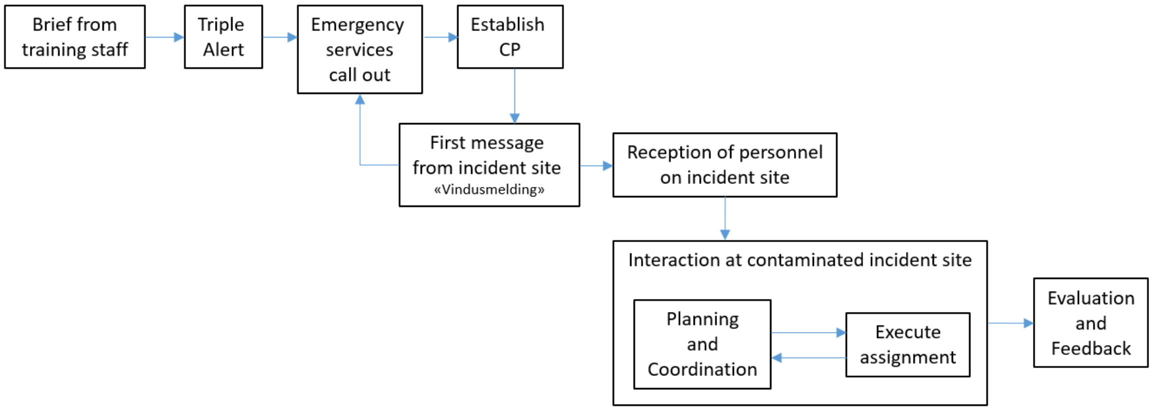


Figure 3.2 Conceptual model of the course of action for the users during the scenario training with the CBRNE-ACT system.

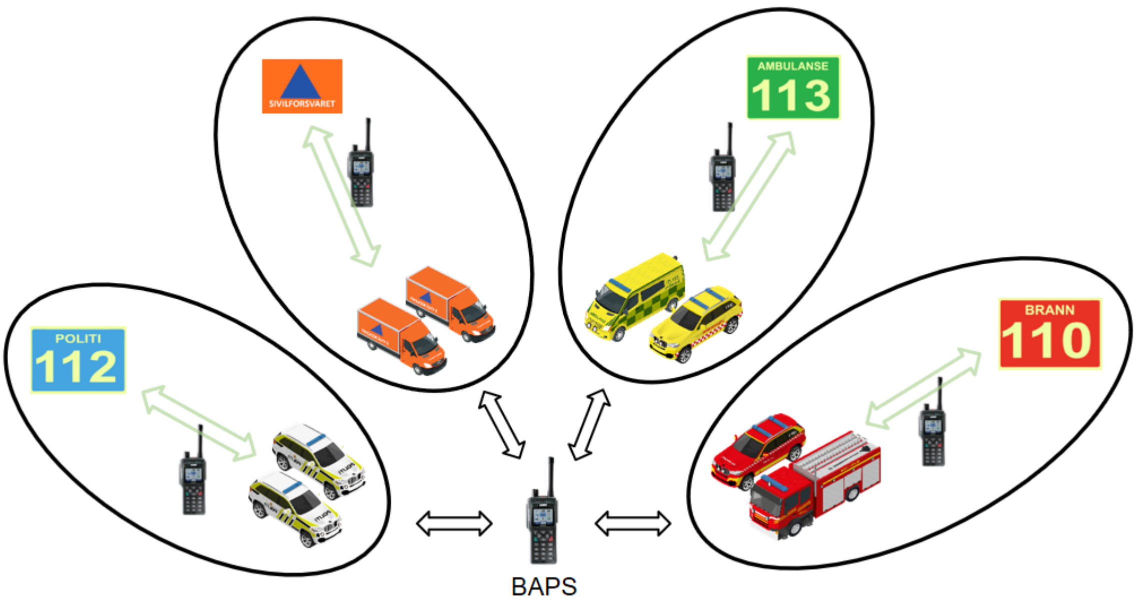


Figure 3.3 Joint radio communication on Nødnett radios using a BAPS channel, on the way to the scene of the incident until all actors have arrived.

3.2.3 Establishing a command post and scene management

The first actor that arrives at the site of the incident will establish a CP at a safe location while having situation awareness of the site. They will then start managing the scene ("Hot zone management") according to figure 3.4. Determining the presence and concentration of a toxic agent, type of agent and the direction of the wind are all critical. This will be decisive when considering where to establish the different zones around the incident location and where to place the first responders and other actors that are involved, as shown in figure 3.4. For cases involving a contaminated incident site, it will be necessary to have a dedicated area for cleaning contaminated victims.

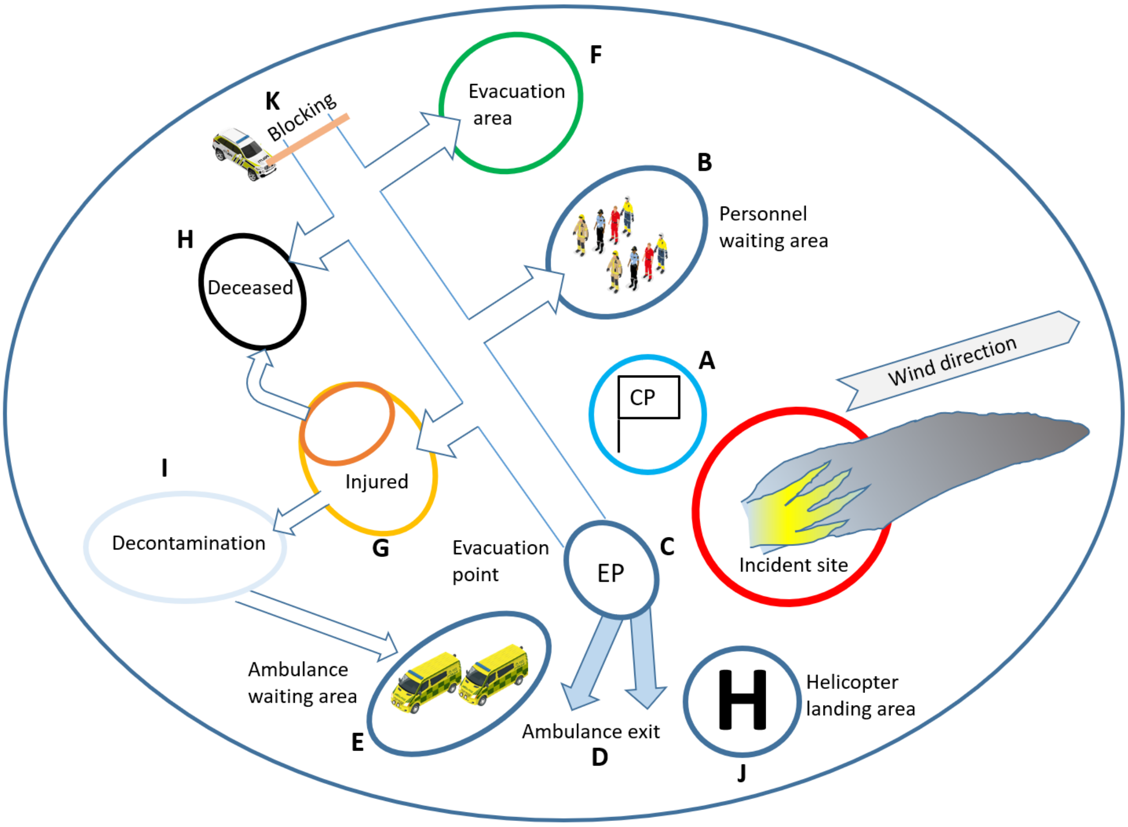


Figure 3.4 Organization of the emergency services' work at a contaminated incident site[2].

[2] This figure is based on a drawing from the civil defence course *Interaction on a contaminated incident site*.

3.2.4 Planning and solving the assignment

The incident commanders will mainly stay in the CP. From the CP, the incident commanders will coordinate with and receive orders from their operation centres through *Nødnett*. The second in command will update the incident commanders on the situation at the scene. The incident commanders will issue orders to the second in command that will pass on the orders to the first responders at the site, as shown in figure 3.5.

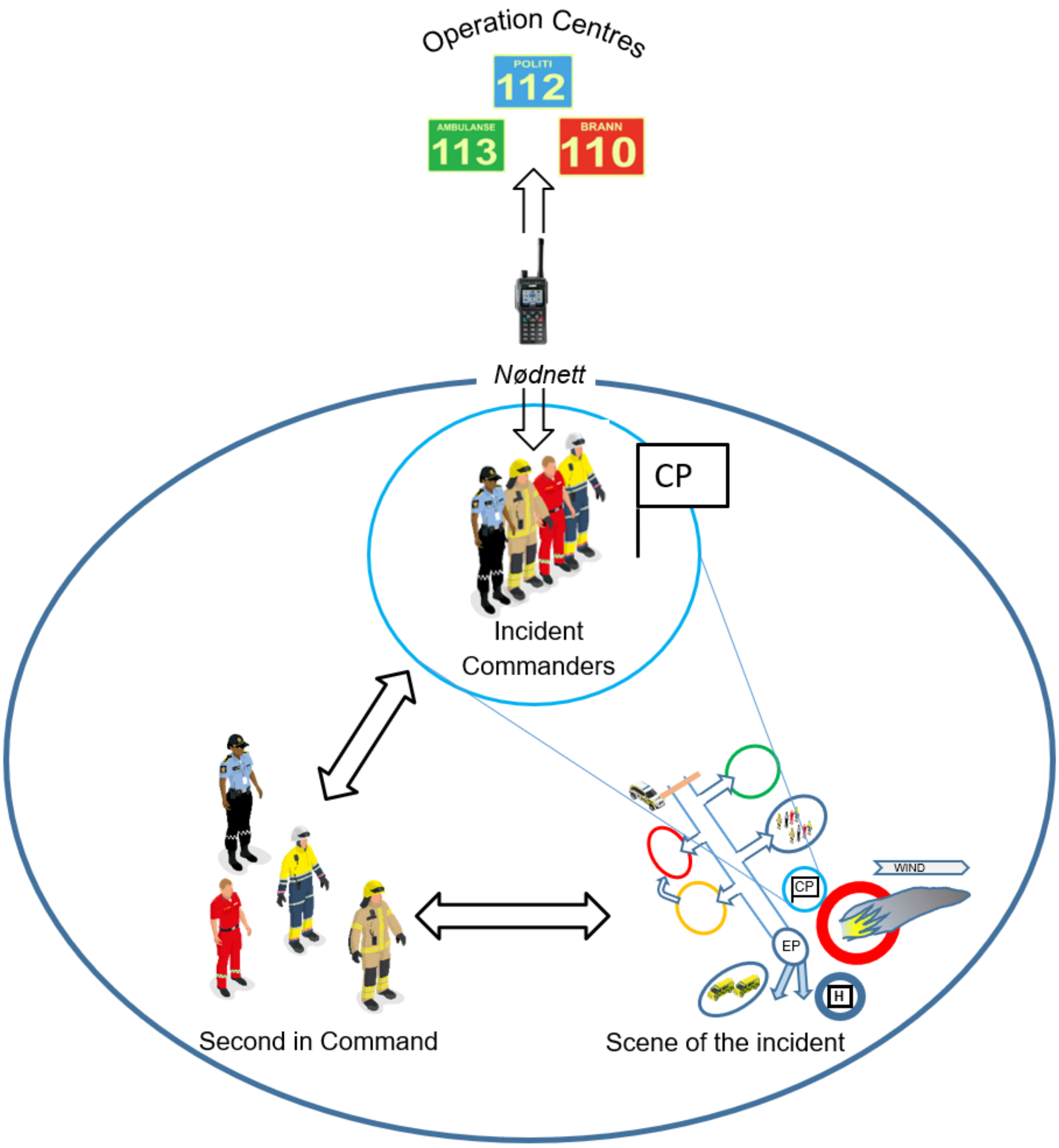


Figure 3.5 Collaboration between the incident commanders and second in command on the scene of the incident.

3.3 Trainee user requirements

This section describes what the functionality and equipment that shall be available to the trainees during a training session. From the generic training objectives, a set of specific requirements below are defined for the training audience. The requirements are categorized into different groups: the equipment used by the trainees and simulation system requirements for the trainees.

3.3.1 Personal equipment and tools available at the command post

The trainees shall be able to communicate using real equipment:

UR-1: Each trainee shall be able to communicate using one or two real *Nødnett* personal radio devices.

UR-2: Five different radio channels shall be available. One common BAPS channel, one dedicated channel for each of the three emergency services and one channel for the civil defence.

UR-3: The trainees shall be able to use two different radio channels at the same time. One common BAPS channel and one channel dedicated to the emergency service the user belongs to.

UR-4: The trainees shall be able to receive phone calls, text messages, pictures, and videos from the area of the incident before arriving at the scene.

UR-5: Each emergency service shall have access to a printed map of the surrounding area when they are in the room that represents their car on the way to the incident.

UR-6: The trainees shall be able to draw on the map using a marker pen.

With tools on site, we mean the tools that are needed in addition to the simulation system CBRNE-ACT.

The requirements for tools on site are:

UR-7: The trainees shall have access to a whiteboard.

UR-8: The trainees shall have access to a large, printed map of the area of the incident.

UR-9: The trainees shall be able to use their *Nødnett* radios.

UR-10: One trainee at the time shall be able to observe the scene of the incident with binoculars (by use of HMD).

3.3.2 Simulation system

The simulation system CBRNE-ACT will mainly be operated by simulator operators, but the trainees are able to perform a limited set of functions according to their role. However, the trainees will be supported by instructors and simulator operators. The trainees shall be able to perform themselves or request the simulator operators the following functions:

UR-11: Move a unit to a desired location. Either simulated movement of the unit or magic move (drag and drop) to its new location.

UR-12: Embark and disembark humans to/from vehicles.

UR-13: Observe the scene of the incident from an oversight position in 3D.

UR-14: Observe the scene in VR from different locations and zoom level to simulate the use of binoculars.

UR-15: Identify vehicle United Nations (UN) number to identifying dangerous goods, hazardous substances, and articles (such as explosives, flammable liquids, toxic substances, etc.).

UR-16: Define zones for different degrees of danger (Hot/Warm/Cold).

UR-17: Set locations and define all the different areas shown in figure 3.4:

A. Set location for the incident commanders CP.

B. Define the personnel waiting area.

C. Set location for the evacuation point.

D. Define the ambulance exit route.

E. Define the ambulance waiting area.

F. Define the evacuation area.

G. Define the area for injured people.

H. Define the area for deceased people.

I. Define the decontamination area.

J. Define the helicopter landing area.

K. Set locations for roadblocks.

UR-18: Evacuate persons in a larger area with text message notification.

UR-19: Give orders to civilian units in the area to move to a location.

UR-20: Secure areas with barrier tape.

UR-21: Set up roadblocks.

UR-22: Stop and redirect vehicle traffic.

UR-23: Evacuate persons in hazard zones.

UR-24: Move persons to a safe place.

UR-25: Move injured persons to hospital with ambulance (by magic move).

UR-26: Decontaminate patients exposed to toxic substances.

UR-27: Cool tank by use of water to reduce dispersion of gas.

UR-28: Cover the tank with a tarpaulin to stop or reduce the leak.

3.4 Instructor and training staff user requirements

The instructors and training staff have been involved in creating the scenario and they will guide and support the trainees before and under the training. For the training staffs and instructors, the following functions shall be available:

UR-29: They shall be able to observe the simulated entities and gas dispersion on a map (2D).

UR-30: They shall be able to view the 3D synthetic environment from different locations and celestial directions.

UR-31: They shall be able to interact with trainees via radio or oral communication.

UR-32: They shall be able to control/change simulation speed – start, stop, pause the simulation execution.

UR-33: They shall be able insert named bookmarks at given times or at important events into the exercise log.

UR-34: The instructors shall be able to listen to and talk on the common BAPS channel.

3.5 Simulation operator and simulation system requirements

The simulator operators shall be able to perform the following functions:

UR-35: The simulator operator shall be able to define and control the movement of the emergency services vehicles. The route to follow can be set manually or be automatically calculated using a road network.

UR-36: The simulation system shall be able to generate background traffic with road vehicles and pedestrians.

UR-37: The simulation system shall be able to simulate people/crowd behaviour.

UR-38: The simulation system shall be able to simulate and display dispersion of hazardous gas.

UR-39: The simulator system shall be able to simulate the effect of gas on persons taking into consideration protection gear and MOPP level (Mission Oriented Protective Posture)

UR-40: The simulator operator shall be able to execute magic moves on simulated objects.

UR-41: The simulator operator shall be able to change the amount of gas dispersion if leak is reduced or stopped.

UR-42: The simulator operator shall be able to control/change the simulation speed. In most cases the simulation will only be run in real time.

UR-43: The simulator operator shall be able to initiate synchronized logging of voice communications and the simulation execution data.

UR-44: The simulator operator shall be able to insert bookmarks into the event log (named timestamps).

UR-45: The simulator operator shall be able to replay whole or parts of the training session including voice recordings.

3.6 Non-functional user requirements

All trainees and instructors must wear vests that show their role in the training session. The use of *Nødnett* on the scene of the incident may be limited if all people and systems are in one room.

UR-46: The trainees shall use vests during the training session indicating their role.

UR-47: The system shall use the IEEE 1516.2010 High Level Architecture.

UR-48: The system shall use the NATO Education and Training Network (NETN) CBRN FOM module to exchange dispersion data.

4 Training system design

The training system consists of applications (federates) that use the distributed simulation architecture and standard – High Level Architecture (HLA) [5, 6, 7]. The federates will exchange data and interactions using an HLA Runtime Infrastructure (RTI) as shown in figure 4.1.

CBRNE-ACT will use VR-Forces [8] for scenario simulation and VR-Vantage [9] for 3D visualization. The 3D visualization may use a monitor or the Varjo XR-3 [10] Head Mounted Display (HMD) (a VR headset). The dispersion of a hazardous substance is simulated by the dispersion federate. The dispersion contour data has been pre-computed using a high-fidelity Large Eddy Simulations (LES) code [11, 12] and stored for offline use by the dispersion federate. The effect from the gas, on people staying in areas with gas, are inflicted on them by the CBRNE effects federate. The dispersion simulation for CBRNE-ACT is described in [13].

The radio communication on the BAPS channel will be distributed into the simulation network, and all relevant data on this network will be logged using an HLA logger. The logged data can be replayed with the logger for use in an after-action review, to give feedback from the instructors to those who are trained.

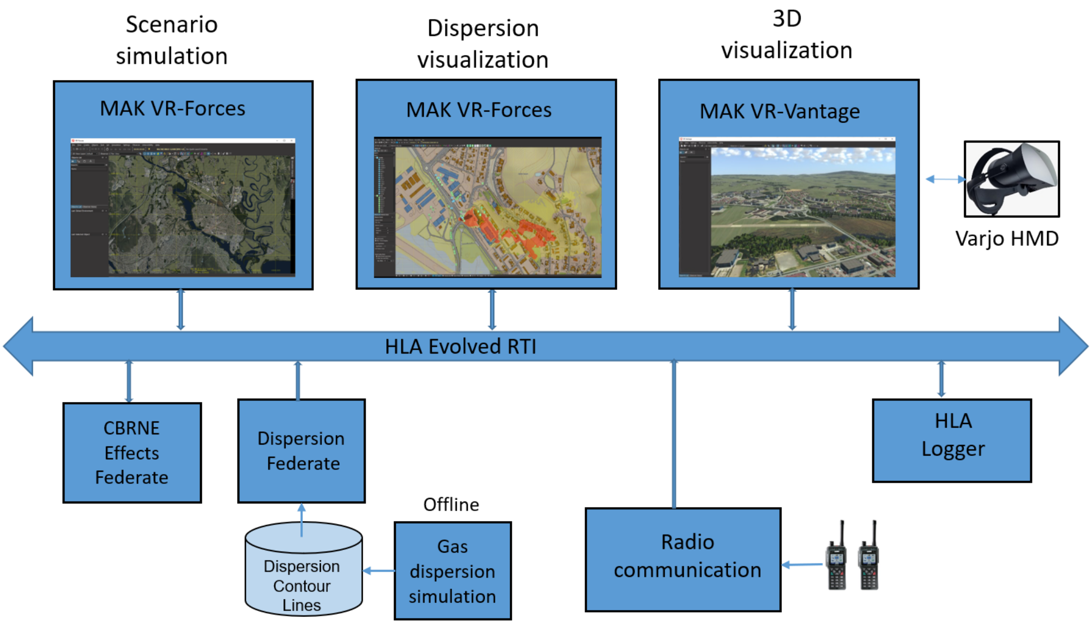


Figure 4.1 CBRNE-ACT system components and applications.

4.1 Entity simulation

VR-Forces is a Commercial Off-The-Shelf (COTS) Computer Generated Forces (CGF) application and toolkit developed by VT MAK. VR-Forces is a joint simulation tool with predefined models of land, air, and sea entities as well as civilian units. VR-Forces has simple models of civilian crowds and traffic patterns.

VR-Forces is split into two separate components: a front-end (graphical user interface) application, and a back-end (simulation engine) application. The front-end can display the synthetic environment in 2D or 3D. VR-Forces comes with a "Simulation Object Editor" that lets the user define and edit Simulation Model Sets (SMS) containing the parameters of the simulation objects. The user can add new simulation objects or tactical graphics types. Sensors, weapon systems and other components can be changed, added, or removed. The user can change the 2D or 3D model used to represent them in the front-end. The new entities and resources configured in VR-Forces for this scenario are given in appendix A.

VR-Forces supports both the Distributed Interactive Simulation (DIS) [14] and HLA standards. VR-Forces can therefore be included as one of the components in a distributed simulation.

4.2 3D visualization using the Varjo HMD

The first responder shall be able to observe the disaster area using MAK VR-Vantage connected to a Varjo HMD. "VR-Vantage is MAK's configurable desktop Image Generator (IG) for out-the-window (OTW) scenes, camera views, and sensor channels. Its built-in distributed rendering architecture supports many different display configurations — from simple desktop deployments to multichannel displays for virtual cockpits, monitor based training systems, even head mounted displays for VR/MR".[3] A binocular effect can be achieved by zooming the view in the VR headset as shown in figure 4.2. This allows an observer to be located further away from the incident, and still be able to observe and report details. To increase performance, the synthetic environment database used in VR-Vantage covers a smaller area than the one used in VR-Forces.

[3] MAK's description of VR-Vantage [9]

Figure 4.2 Binocular effect for an observer looking into the synthetic environment using the Varjo HMD.

4.3 Screen recording

OBS Studio [15] is a free and open-source software for high-performance real-time video/audio capturing and mixing. Scenes can be made from multiple sources including window captures, images, text, browser windows, webcams, capture cards and more.

As an alternative method to record the Varjo HMD view, the Varjo Base [16] software can be used. The image from VR that can be seen on the screen, and recorded, is only a small view of what the user really sees in the VR glasses. Screen recording is useful for after-action review or for making instructional videos.

4.4 Communication system

A FFI developed DIS/HLA-voice application called BRAGE [17], is used to send radio communication data over DIS [14] or HLA [5, 6, 7]. The radio is connected to a computer running BRAGE as shown in figure 4.3. All radio communication can be logged by a DIS/HLA recorder. Due to a missing solution for connecting the radios by wire to the computer running BRAGE, an ad hoc solution with an insulated box with a microphone inside was used.

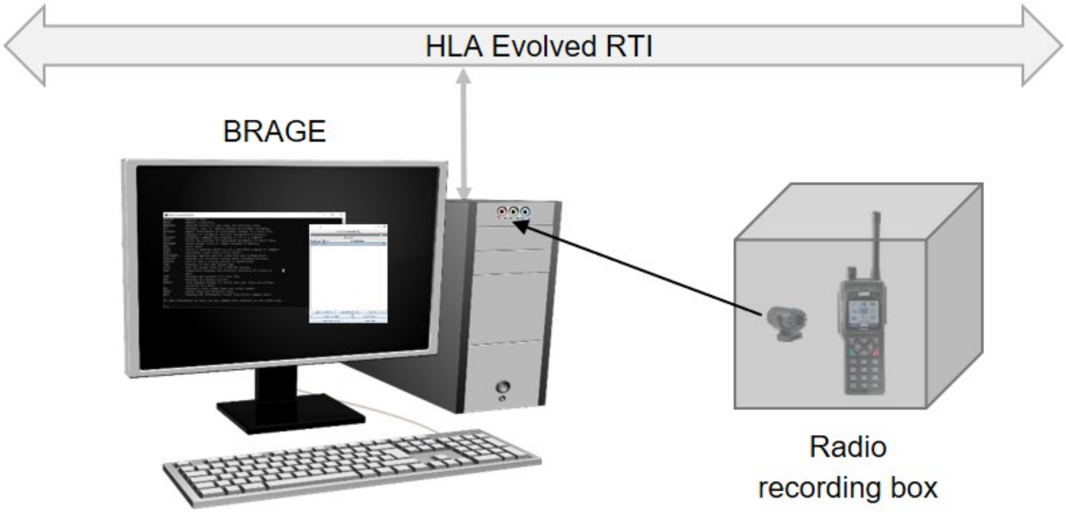


Figure 4.3 System for sending radio communication to the simulation network.

4.5 Dispersion Simulation

The dispersion federate transmits the concentration and extent of the gas cloud to the other simulation components over HLA. Since determining the dispersion of gases can involve quite complex calculations, this dispersion is not calculated on the fly. Instead, the dispersion simulation reads the gas dispersion from pre-calculated data files. For this particular scenario (section 3.1), a high-fidelity 3D wind and dispersion simulation (LES) has been applied to account for urban effects such as buildings and terrain. We refer to [13] for more information on the pre-calculated dispersion simulation.

The dispersion of the gas is transmitted to other simulation systems over HLA using the *RawDataHazardContourGroup* object defined in the NETN CBRN FOM. The federation object model is described in chapter 4.11 and the NETN FOM [18] is described in chapter 4.11.2.

The results from the 3D dispersion simulation are post-processed, resampled onto a regular grid (with 5 meter resolution) and stored at planes two meter above ground before it is transmitted. To ensure a smooth running of the CBRNE-ACT scenario, the data is stored in time series with a temporal resolution of 30 seconds to avoid too much data transfer[4]. For each time step, the dispersion data is represented as a set of contours, each contour giving the concentration level in PPM (parts per million).

The data for each contour starts with the time at which the contour is valid, stored as a 32-bit floating point number as specified in the IEEE 754 standard. Next, the agent type is stored as a

[4] The 3D wind and dispersion simulation has been computed with a temporal resolution $t=0.02$ seconds. A denser time sampling than 30 seconds of the dispersion used in CBRNE-ACT can therefore easily be obtained.

16-bit integer, and the hazard type is stored as an 8-bit integer. The values of these integers are set according to the value tables for the *AgentTypeEnum16* and *HazardTypeEnum8* datatypes of the NETN CBRN FOM. The gas concentration of the contour is stored as a 32-bit floating point number. The next data value is a 16-bit integer storing the number *n* of coordinates that define the contour, and the next *2n* values are 32-bit floating point numbers that define the x and y values of each coordinate point. The coordinates are given in a Cartesian coordinate system with units of meters, and with a previously agreed origin and orientation.

Contours are read one by one from the data file until there is no more data left to read. Contours are only valid from their timestamp until the lowest timestamp that is larger than the contour's timestamp. All contours are therefore expected to be redefined at each timestamp stored in the data file for as long as they exist.

4.6 CBRNE effect simulation

The CBRNE effect simulation is an HLA federate which calculates the effects of the dispersed gas on the people being simulated. The federate receives both the dispersion of the gas and the position of simulated people over HLA and calculates an accumulated exposure for each person. Once the accumulated exposure crosses certain thresholds, the simulated person is incapacitated, injured, or killed. The 10-minute Acute Exposure Guideline Levels (AEGLs) are used as the threshold levels for different effects. AEGL-1 is the concentration threshold above which affected people could experience discomfort or irritation, AEGL-2 is the threshold above which exposed people could experience irreversible or long-lasting effects and an impaired ability to escape, and AEGL-3 is the threshold above which exposed people could experience life-threatening health effects or death [19].

The CBRNE effect simulation federate depends on the simulated people being represented by the *CBRN_Human* data type from the NETN CBRN FOM, and on that the federate that created the people objects is willing to divest its ownership of the *TriageLevel* attribute of this data type. The CBRNE effects federate takes ownership of this attribute and sets its value depending on how injured the simulated person has become. The transmitting federate should then use the value of this attribute to set an according damage state for the simulated person.

4.7 Dispersion visualization

A plugin was written to display the gas dispersion in the VR-Forces front-end. This plugin reads the contour values from the HLA federation, and draws the contours in VR-Forces, as illustrated in figure 3.4. The colour of the contour is determined by the concentration of gas, and threshold values for concentration were chosen such that yellow areas correspond to concentrations above 10 minute AEGL-1, red areas above 10 minute AEGL-2, and black areas correspond to concentrations above 10 minute AEGL-3.

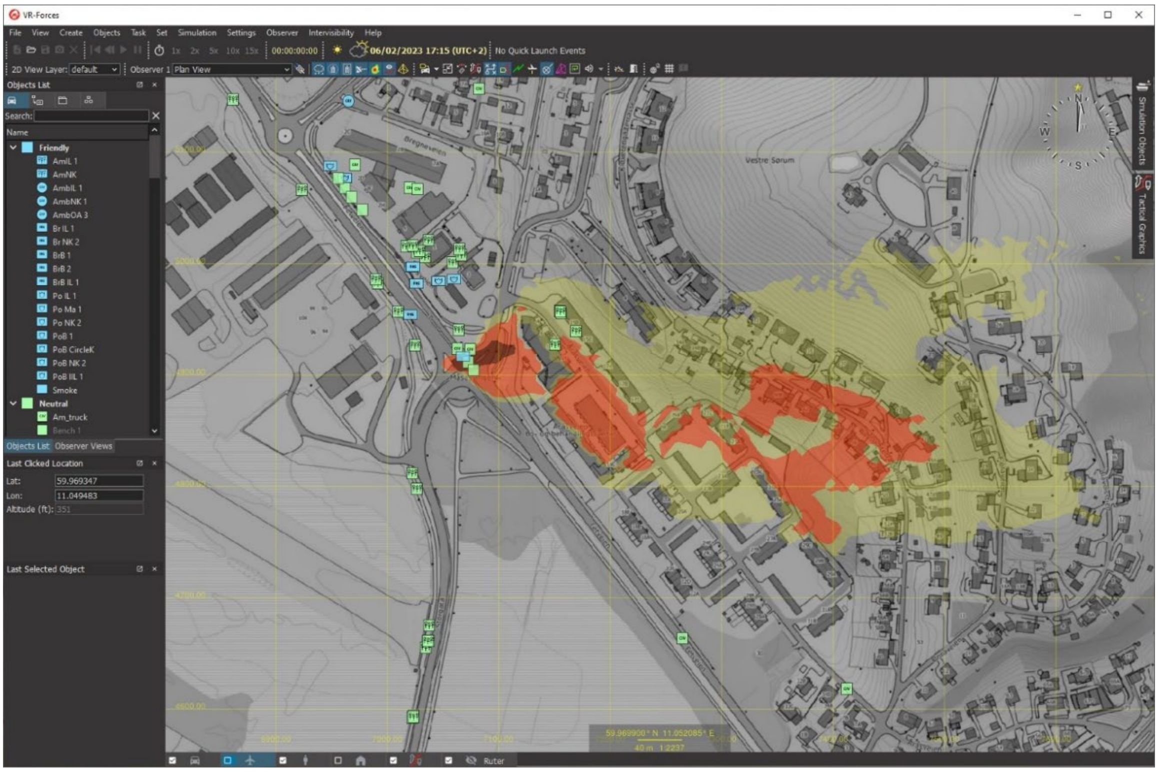


Figure 4.4 Gas concentration contours visualized in the VR-Forces front-end with plugin.

4.8 Simulation environment development

The simulation system, which previously has been used for the simulation of gas emissions, has been further developed and adapted for training emergency services at a contaminated incident site as shown in figure 4.5. Using VR headsets in a realistic 3D environment will give an actor who is close to the incident a better opportunity to observe and report what has happened.

The simulation system is using the HLA IEEE 1516.2010 (HLA Evolved) standard [5, 6, 7]. A detailed synthetic environment for a specific area has been created, and VR-Forces has been configured with new entities, objects, and tactical graphics for the new scenario. Figure 4.6 shows new 3D models created for the scenario.

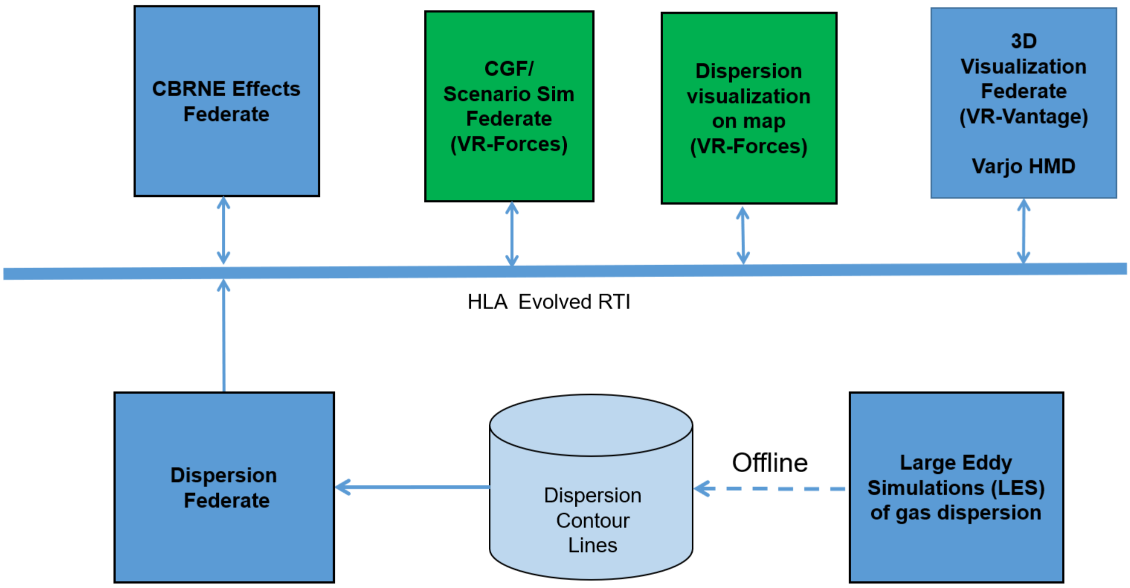


Figure 4.5 Simulation environment for simulation and visualization of gas dispersion.

Figure 4.6 New 3D models created for the scenario.

4.9 Physical environment database

The simulation system needs a physical environment database and figure 4.7 show the source data and tools needed for the database creation. A terrain database is used in VR-Forces front-end for visualization, in the back-end for simulation and for visualization in VR-Vantage with HMD. Figure 4.8 and figure 4.9 show two terrain databases created for CBRNE-ACT.

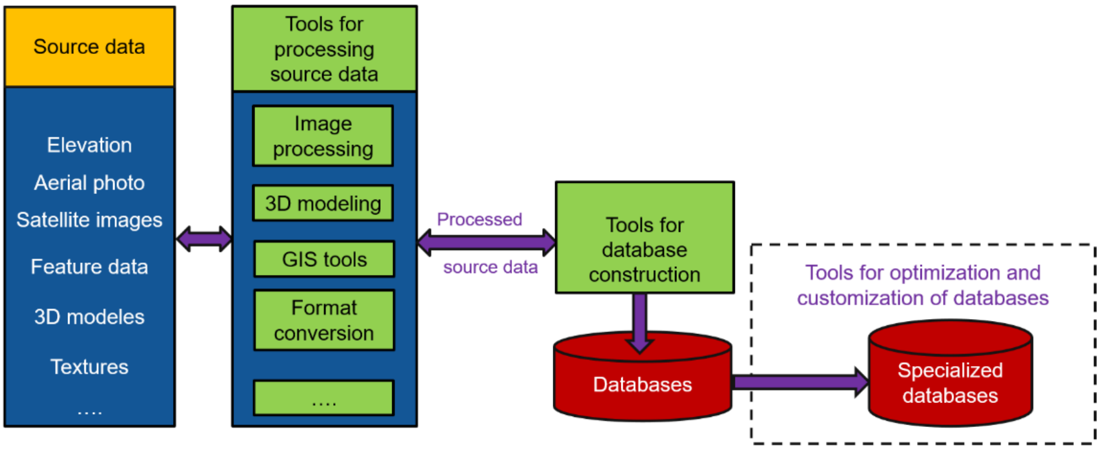


Figure 4.7 The source data and tools needed to create terrain databases for simulation systems.

Figure 4.8 Oslo database used for a scenario with a train incident at Oslo Central Station.

Figure 4.9 Kjeller database created for the ammonium scenario.

The terrain database used in VR-Forces is created with Terra Vista (TV) from Presagis. The database covers a 10 x 10 km area around the scene of the incident (red rectangle in figure 4.10). The same terrain database is used by both the VR-Forces front-end and back-end. A smaller database for use in VR-Vantage with HMD is also created (violet rectangle in figure 4.10).

A small area in both databases (3.5 x 2.5 km) has a higher level of detail (LOD) as shown in figure 4.10 (blue rectangle). Figure 4.11 shows the database used in the VR-Forces front-end (2D).

Most of the buildings in the high detail part of the databases are created automatically from their footprint vectors and estimated wall heights. Textures are chosen randomly from a predefined small selection of images. A few buildings near the incident site are given more realistic textures from photos. Figure 4.12 shows a 3D-view of the buildings near the incident site visualized in the VR-Forces front-end.

Figure 4.10 The databases are built with two different levels of detail. The red rectangle shows the database area for VR-Forces, and the smaller violet area shows the database area for VR-Vantage with HMD. In both databases, the blue area has a higher level of detail.

Additional databases textured with raster maps, mainly intended for use in the front-end 2D interface, are shown in figure 4.13 and figure 4.14.

The source data used to create the Kjeller databases are:

- DEM10 elevation data (10x10 meter grid).
- Aerial photos (resolution: LOD_1 – 1 meter, LOD_3 – 20 cm).
- Raster background maps for the dispersion visualization.
- Vector data (areas, lines and points).

- Building footprints in the LOD_3 area.
- Road vector data.
- Single tree points.
- Prebuilt 3D-model positioning points (created manually) for buildings, road signs and other objects.
- Land usage (forest, river, lake, agriculture, industrial, residential or other).

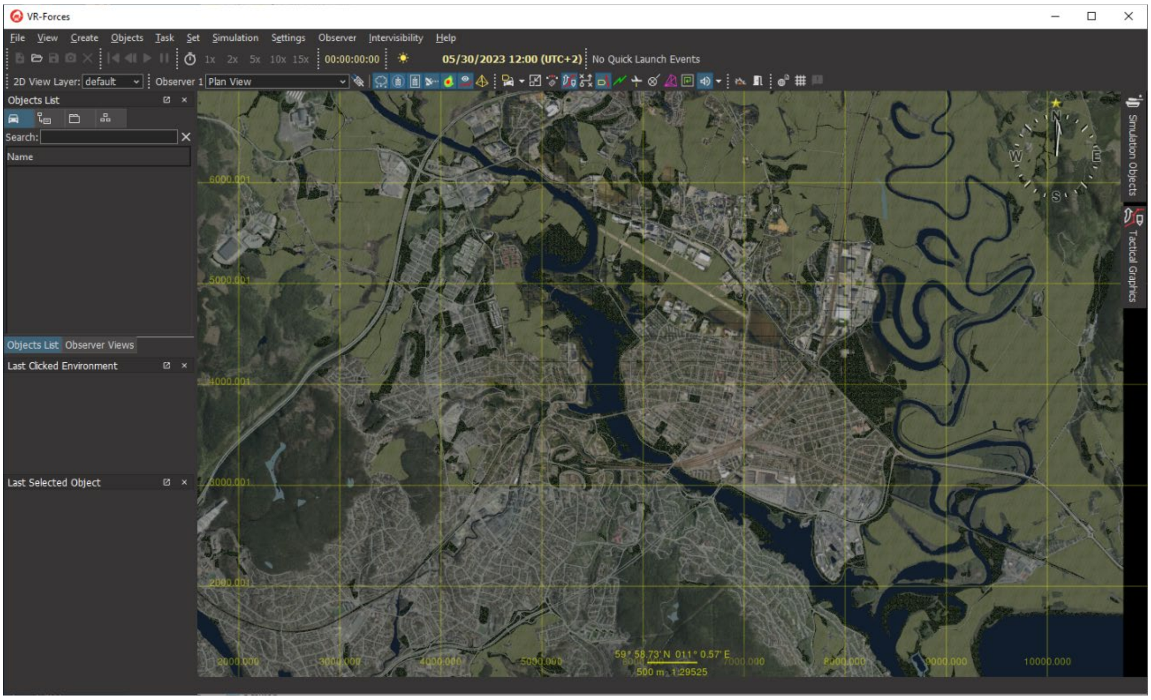


Figure 4.11 Detailed terrain database shown in VR-Forces front-end (2D-view).

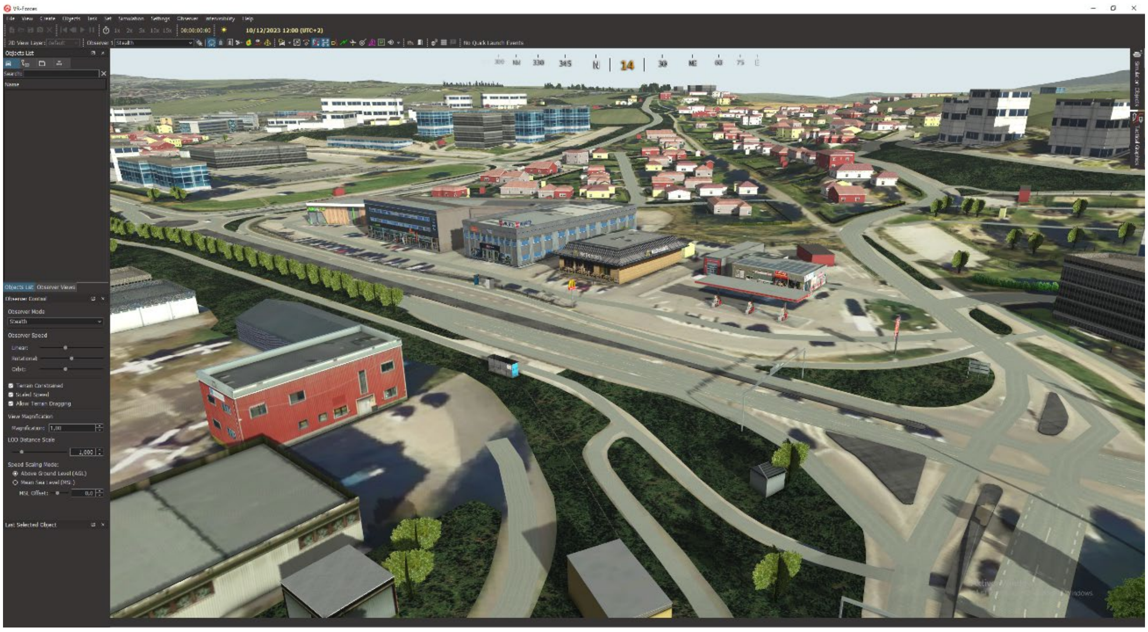


Figure 4.12 Details in the terrain database shown in VR-Forces front-end (3D-view).

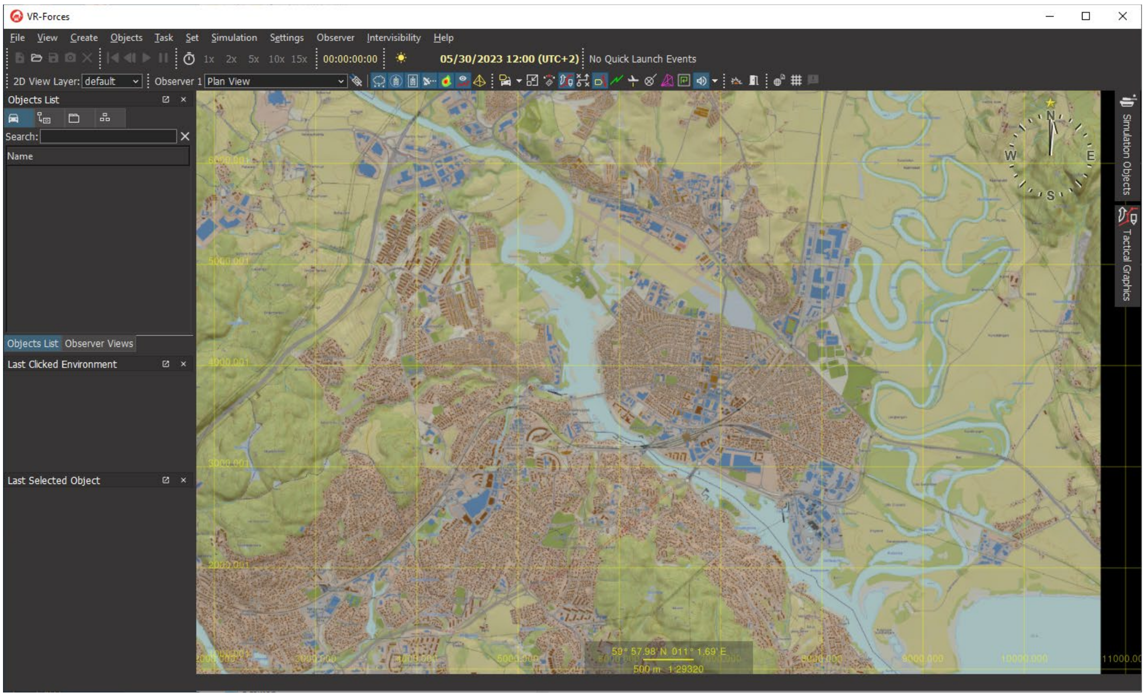


Figure 4.13 Terrain with colorized map in VR-Forces front-end (2D-view).

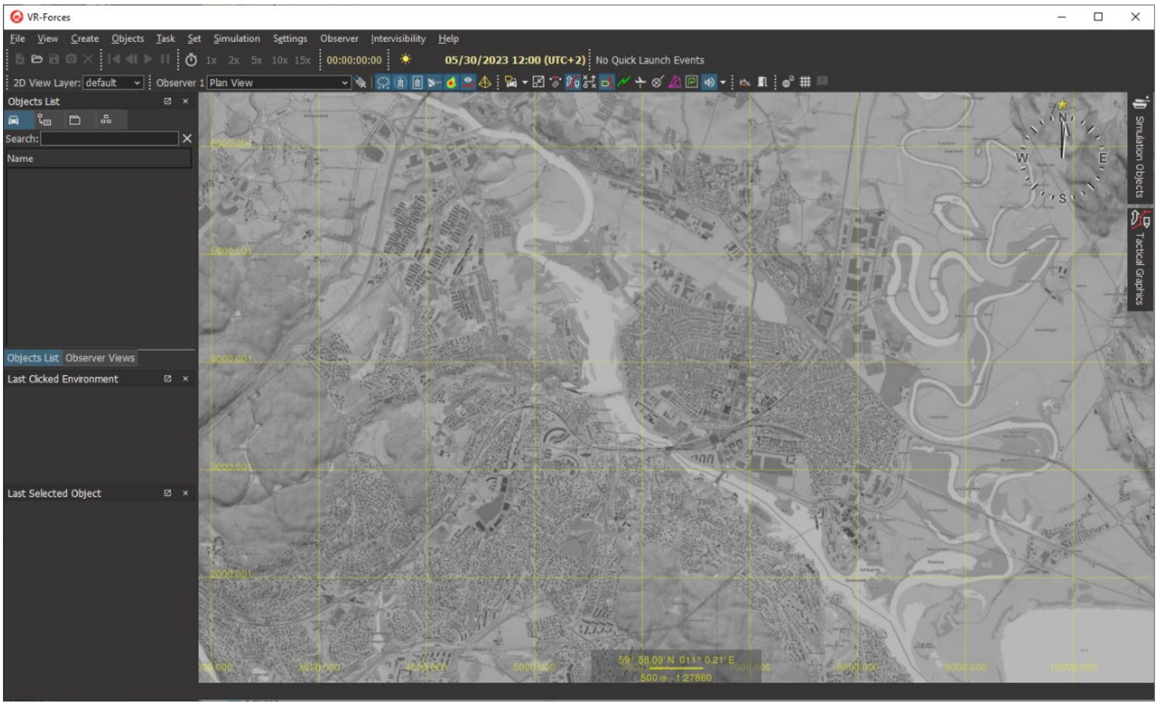


Figure 4.14 Terrain with grayscale map in VR-Forces front-end (2D-view).

4.10 Scenario development

VR-Forces is customizable, and the "Simulation Object Editor" can be used to configure existing object models and add new simulation object models. VR-Forces has support for vehicle and lifeform "Patterns of Life" to enrich the scenario with entities that are not directly involved in a scenario. By adding road vector data to a VR-Forces terrain database, entities can be given orders to follow roads as they travel from one place to another. The user can set up sinks that generates random pedestrians or vehicles starting from this point, and travel to a random selection of sinks, where the newly created entities will be deleted from the simulation. People can also be given the task of walking around within a user defined area. People can embark in a vehicle and disembark when the vehicle reaches its destination.

Each simulation object can be given a predefined plan to follow at run-time. A plan is a collection of tasks to perform and the definition of conditions under which the plan may vary. The simulation object tries to execute this plan. Plans can be edited, saved, and reused. One important functionality in a plan is the use of triggers. A trigger has a condition and a block of statements that are executed when the trigger condition becomes true. One example can be that if a person receives a specific text message, for instance "evacuate", the user can make a block of statements that makes this person run to a specific location. Pre-programmed global plans can be executed by pressing the corresponding buttons in the VR-Forces front-end.

4.11 Federation Object Model

The HLA Runtime Infrastructure (RTI) will be using the HLA evolved standard to exchange information between the different federates using a data model. HLA requires that the type of data to exchange is specified in a document called a Federation Object Model (FOM). A FOM specifies the set of objects and interactions that may be exchanged in a federation, and the data fields these contain. These data fields are called attributes for objects and parameters for interactions.

Object and interaction classes may inherit from other classes. A class that inherits from another class contains all the data fields of its parent class, and may define its own, additional data fields. It is also possible to create FOM modules that extend an existing FOM. Such a FOM module may define object and interaction classes that inherit from classes in the original FOM.

The different federates in a federation are not required to all use the same set of FOM modules. The RTI ensures that each federate only receives objects and interactions that exist in the set of FOM modules that the federate uses. In case a federate receives an unknown class that extends one of the classes that the federate knows about, the RTI can strip away the extra data fields so that the federate receives the object as a known class with only known data fields.

The FOM and FOM modules used in CBRNE-ACT are listed in appendix B.

4.11.1 Real-time Platform Reference Federation Object Model (RPR FOM)

The RPR FOM [20] was developed to ease the transition from the Distributed Interactive Simulation (DIS) [14] protocol to HLA. It defines a set of object classes and interactions that closely mirrors the data structures available in DIS, which makes it easy to translate between DIS and RPR FOM.

The RPR FOM is very commonly used in military simulations and allows the exchange of information about object classes such as military platforms, human and non-human lifeforms, buildings and sensors, and interaction classes such as weapon fires, detonations, radio transmissions and collisions.

4.11.2 NATO Education and Training Network FOM (NETN FOM)

Since the RPR FOM was created to closely mirror DIS, it does not take advantage of many of the features of HLA. The NETN FOM [18] was created to extend the RPR FOM, both to take advantage of these HLA features and to be able to represent new object classes and interactions that are not represented in RPR FOM and DIS.

The NETN FOM is split into several modules that each cover a separate domain, such as tasking and reporting, multi-resolution modelling, or logistics. In CBRNE-ACT, we use the NETN CBRN module, which covers CBRN release, detection, effects, and protective measures.

4.12 Simulation environment federation agreement

All federates shall join the federation using ***MAK-RPR-2.0*** as the federation name. The software versions used in CBRNE-ACT is given in appendix C.

Scenarios are created by placing entities in a synthetic environment. It is also possible to create routes and waypoints and assign tasks, set state parameters, and create plans that have tasks with conditional statements.

All simulated entities shall use their corresponding CBRN object class as defined in the NETN CBRN FOM (such as *CBRN_Human* or *CBRN_GroundVehicle*), and simulation systems shall be ready to divest their ownership in the TriageLevel attribute of their units.

Once the simulation components have divested ownership in the *TriageLevel* attribute, they shall listen to changes in its value, and use this value to determine the damage state of their own units.

5 Integrating and testing the simulation environment

To test and integrate CBRNE-ACT at FFI, a local network connected to the Internet through a gateway was set up, and the applications was distributed on four different computers as shown in figure 5.1. Since configuration and scenario development was done on different computers, it was important to configure and test VR-Forces and VR-Vantage on the new system. Both VR-Forces and VR-Vantage are based upon the same 3D visualization components and will use common shared data packages.

Appendix D covers how to copy MAK configuration files from a customized installation on to a new computer.

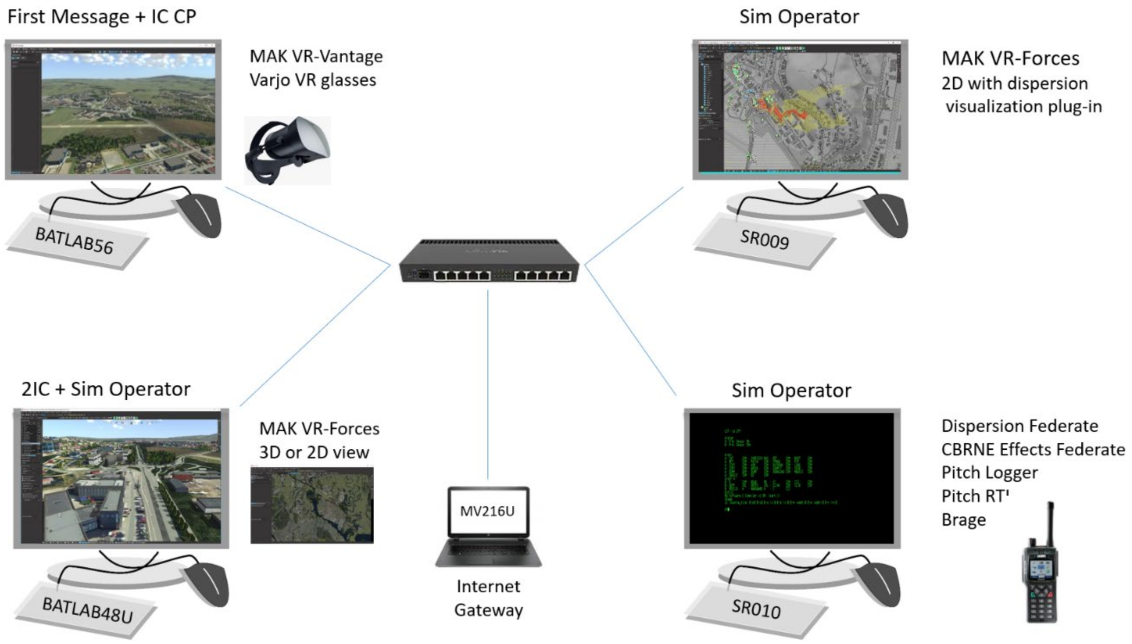


Figure 5.1 Computers and applications used during integration tests of CBRNE-ACT.

5.1 Testing the simulation environment

The VR-Forces plugins can be tested by starting up the Dispersion and Effects federates and connect them to the federation. The following tests have been made:

- Inspect the drawing of the three different gas concentration levels in the VR-Forces front-end 2D visualization and place human entities at different locations, some outside and some inside the areas exposed to gas.

- Open the information dialogue boxes and examine the damage state. The user can verify the simulated human's postures in the 3D view as shown in figure 5.2.

Figure 5.2 Three of the four different damage states visualized in 3D.

To test the configuration of VR-Forces and VR-Vantage, both systems are connected to the same federation. For all the customized entities and tactical graphics created in VR-Forces, the following check-list is used:

- Visually inspect that the object icons are correctly shown in the 2D view.
- Check that all the 3D-models are correctly visualized in VR-Forces and VR-vantage 3D view.
- Check if articulated parts of 3D-models are displayed correctly. Rotating wheels on moving entities should rotate correctly when looked at from the left or right side of the object.
- Check that damage models are displayed correctly by manually setting the damage state for the object.
- Check that embarkation and disembarkation points for vehicles are configured correctly.
- Simulation data and interactions shall also be inspected in the Pitch Recorder application.

6 Conclusion

Realistic live training on CBRNE incidents may require a lot of vehicles, personnel and time used for preparation of the exercise area. The use of computer simulation in a virtual environment are useful for both CBRNE incident training and education. As part of the collaborative Polish-Norwegian project "Strengthening CBRNE safety and security – Coordination and Standardization", FFI has developed a simulation-based training system for CBRNE training – CBRNE Accident Coordination Training (CBRNE-ACT). CBRNE-ACT builds on an existing demonstrator at FFI and is based on military simulator technology and standards.

This document describes the user needs and requirements, design, and implementation of CBRNE-ACT. FFI has used a standard process for the development of distributed simulation system when developing CBRNE-ACT, namely the Distributed Simulation Engineering and Execution Process (DSEEP). This document outline is in accordance with the DSEEP steps.

CBRNE-ACT is a component-based system where the components communicate using international and NATO standards. This allows for ease extension of the system and reuse of components. The use of the distributed simulation standard High Level Architecture also enables connecting CBRNE-ACT to other (military) training systems.

Abbreviations

2D	Two-dimensional
2IC	Second In Command
3D	Three-dimensional
AEGL	Acute Exposure Guidelines Levels
CBRNE	Chemical, Biological, Radiological, Nuclear, and Explosive materials
CGF	Computer Generated Forces
COTS	Commercial off-the-shelf
DIS	Distributed Interactive Simulation
DSEEP	Distributed Simulation Engineering and Execution Process
FOM	Federation Object Model
HLA	High Level Architecture
HMD	Head-Mounted Display
IC	Incident Commander
IG	Image Generator
IEEE	Institute of Electrical and Electronics Engineers
LES	Large Eddy Simulations
LRS	Local Rescue Centre
MOPP	Mission Oriented Protective Posture
MR	Mixed Reality
NATO	North Atlantic Treaty Organization
NETN	NATO Education and Training Network
OTW	out-the-window
RTI	Runtime Infrastructure
SISO	Simulation Interoperability Standards Organization
SMS	Simulation Model Set
TO	Training objective
UR	User requirement
VR	Virtual reality
XML	eXtensible Markup Language
XR	Extended reality

Appendix

A Additional entities and resources configured in VR-Forces

Table A.1 lists all new first responder entities configured in VR-Forces. In a distributed simulation environment, a simulation reference enumeration is used to uniquely identify the different entity types. The reference enumeration types [21] are defined by the following seven fields –kind:domain:country:category:subcategory:specific:extra.

Entities of kind 1 are platforms, of kind 3 are life forms and kind 5 are cultural features. Norway has been assigned the country code 163.

Table A.2-A.5 lists all new resources made available in VR-Forces for use in CBRNE-ACT.

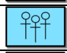
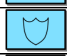
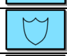
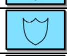
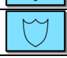
Name	DIS Enumeration	Short Name	2525b symbol	
AmbulanceCar	1:1:163:84:1:1:1	Amb	498d	CIV
AmbulanceCar OA	1:1:163:84:1:1:2	AmbOA	498d	CIV
AmbulanceCar IC	1:1:163:81:113:1:1	AmbIC	498d	CIV
Ambulance M	3:1:163:3:0:1:0	Am-M	55E1	
Ambulance F	3:1:163:3:0:1:1	Am-K	55E1	
Ambulance IC	3:1:163:3:0:1:4	Am-IC	55E1	
FireTruck	1:1:163:84:11:0:0	FiTr	5559	FIRE
FireCar IC	1:1:163:81:113:1:2	FiCIC	5559	FIRE
FireFighter	3:1:163:3:2:6:1	FF-M	5559	FIRE
Fire IC	3:1:163:3:2:6:2	Fi-IC	5559	FIRE
PoliceCar	1:1:163:93:2:5:1	PoC	4581	
Police Van	1:1:163:84:23:1:0	PoV	4581	
PoliceCar IC	1:1:163:81:113:1:3	PoCar	4581	
Police M	3:1:163:3:0:1:2	Po-M	4581	
Police IC	3:1:163:3:0:1:3	Po-IC	4581	

Table A.1 First responder entities in VR-Forces.

Name	DIS-enumeration	Short Name	2525b symbol	
VolvoF16-Ammonium	1:1:163:27:0:0:4	VoAm	498d	CIV
VolvoF16-Red Container	1:1:163:27:0:0:6	VoRC	498d	CIV
VolvoF16-Black Container	1:1:163:27:0:0:7	VoBC	498d	CIV
VolvoF16 Ammonium Trailer	1:1:163:27:0:0:2	VoAm	498d	CIV
VolvoF16 Container Trailer	1:1:163:27:0:0:5	VoCT	498d	CIV
VolvoF16 Hoyer Trailer	1:1:163:27:0:0:7	VoHAm	498d	CIV

Table A.2 Other new civilian entities available in VR-Forces.

Name	DIS-enumeration	Short Name	2525b symbol	
Smoke plume white	1:1:0:150:2:1:1	SmPlW	0032	
Smoke plume white small	1:1:0:150:2:1:2	SmPlWS	0032	

Table A.3 User defined smoke plumes (particle systems).

Name	DIS-enumeration	Short Name	2525b symbol	
Colored Cone_25cm	5:1:1:0:6:4:0:7	CC25cm	0032	
Colored Cone_50cm	5:1:1:0:6:4:0:6	CC50cm	0032	
Traffic Cone_1m	5:1:1:0:6:4:0:4	TC1m	0032	
Traffic Cone_75cm	5:1:1:0:6:4:0:5	TC75cm	0032	
RoadBlock	5:1:1:0:5:25:0:3	RB	0032	
RoadBlockPlank	5:1:1:0:5:25:0:4	RBP	0032	
BT Police 5m	5:1:0:6:25:0:7	BT5m	4581	
BT Police 10m	5:1:0:6:25:0:6	BT10m	4581	
BT Police 20m	5:1:0:6:25:0:8	BT20m	4581	

Table A.4 Available equipment for blocking traffic and people.

Name	DIS-enumeration	Short Name	Icon	Color coding R,G,B
CBRNE Deceased Area	18:0:0:1:0:1:102	Deceased Area		140,0,0
CBRNE Decontamination Area	18:0:0:1:0:1:106	Decontamination Area		85,255,255
CBRNE Evacuation Area	18:0:0:1:0:1:104	Evac Area		16,141,16
CBRNE Injured Area	18:0:0:1:0:1:103	Injured Area		255,255,0
CBRNE Waiting Area	18:0:0:1:0:1:105	Waiting Area		0,0,127
CBRNE Warm Zone	18:0:0:1:0:1:101	Warm Zone		255,85,0
CBRNE Hot Zone	18:0:0:1:0:1:100	Hot Zone		170,0,0
CBRNE CP	16:0:0:3:0:0:101	CP		101,78,174
CBRNE EP	16:0:0:3:0:0:100	EP		32,7,109

Table A.5 CBRNE tactical graphics in VR-Forces.

B FOM and FOM modules

This appendix lists all FOM and FOM modules used during the experiment. Different federates will use the modules necessary for their specific functionality.

B.1 RPR FOM

RPR_FOM_v2.0_1516-2010.xml [20]

B.2 MAK specific FOM modules

MAK-VRFExt-6_evolved.xml

MAK-DIGuy-7_evolved.xml

MAK-LgrControl-2_evolved.xml

MAK-VRFAggregate-3_evolved.xml

MAK-DynamicTerrain-2_evolved.xml

B.3 NATO Education and Training Network (NETN) FOM modules

NETN-BASE.xml

NETN-Physical.xml

NETN-CBRN.xml

C Simulation infrastructure software versions

The application and system version used in CBRNE-ACT is shown in Table C.1

Application/System	Version	Name	Comments
VR-Forces	5.0.2	MAK VR-Forces	CGF with plugins
VR-Vantage	3.0.2	MAK VR-Vantage	3D-visualization with AR/VR/MR support
RTI	5.5.8	Pitch RTI [22]	Run Time Infrastructure for interconnectivity between HLA federates.
Logger	3.1.3	Pitch Recorder [23]	Logger/replayer
Dispersion federate	Latest	App.java	Simulates the dispersion of a gas. Data comes from a dispersion contour repository.
Effect federate	Latest	App.java	Calculating CBRN effects on simulated human units.
Brage	Latest	DisVoice	Radio communication using DIS/HLA.
Varjo Base	3.10.2.20	Varjo Base[16]	Software used to control the headset. The user can observe and record part of what the headset viewer is seeing.
Steam and Steam VR	Latest	Steam, Steam VR [24, 25]	A tool for experiencing VR content.

Table C.1 Simulation infrastructure applications and systems

D Configuring CBRNE-ACT VT MAK products

This appendix covers how to copy MAK configuration files from a customized installation to a new computer, if the MAK installation has been customized by adding new entity types, tactical graphics, particle systems, 3D models and terrain databases. All path names, if not otherwise specified is relative to the different MAK products installation directories. For instance, the VR-Forces *Data* directory for version 5.0.2 is found in the *C:\MAK\VR-forces5.0.2* directory.

D.1 Configuring VR-Forces

- The configured simulation model set (a file and a directory) must be copied to the *Data\simulationModelSets* directory on the new system.
- The scenarios must be copied to the *userData\scenarios* directory on the new system.
- Observer views must be copied to the *appData\settings\vrfGui* directory.
- Configuration use of new vector data attributes in VR-Forces for roads is done by copying the customized *appData\settings\featureconfig.txt* file.
- Copy all NATO FOM xml files to the *bin64* directory in the MAK VR-Forces installation path.
- Copy the batch files for starting front-end with the *VrfDiffusionPlugin.dll* and the back-end with the *VrfDamagePlugin.dll*. This batch files also load all the necessary FOM files and FOM modules and connect to the federation.

D.2 Configuring VR-Vantage

- Observer views must be copied to the *appData\settings\stealth* directory.

D.3 Configuring shared data for both systems

To get the correct definition and visualization of new entities created in an extended customized SMS, in both VR-Forces and VR-Vantage some files from this SMS must be copied to the MAK shared data install. Copy data to the folder:
SharedData\16\latest\ModelData\Configuration\Definitions\Entity\UserData

- Copy all entity *.omxx* files from *gui\visuals\UserData* in the SMS directory.
- Copy all *.leaf* and *.metx* files from *gui\visuals\Entity* in the SMS directory.

To get the correct definition and visualization of tactical graphics created in an extended customized SMS, in both VR-Forces and VR-Vantage some files from this SMS must be copied to the MAK shared data install. Copy the following data to this folder: *SharedData\16\latest\ModelData\Configuration\Definitions\TacticalGraphics\UserData*

- Copy all tactical graphics *.omxx* files from the SMS directory: *gui\visuals\UserData*

- Copy all *.leaf* and *.mtgx* files from the SMS directory: *gui\visuals\Entity*

All new OpenFlight 3D-models created should be placed in a separate *models* directory, located in the root MAK software installation directory (e.g., C:\MAK) on all the computers running VR-Forces or VR-Vantage.

- Particle systems must be copied to *SharedData\16\latest\Particles*

- Terrain configuration must be copied from *SharedData\16\latest\TerrainData\TerrainConfiguration* and *SharedData\16\latest\TerrainData\navData*

The terrain databases should be placed in a separate *terrain* directory in the root MAK software installation directory (e.g., C:\MAK).

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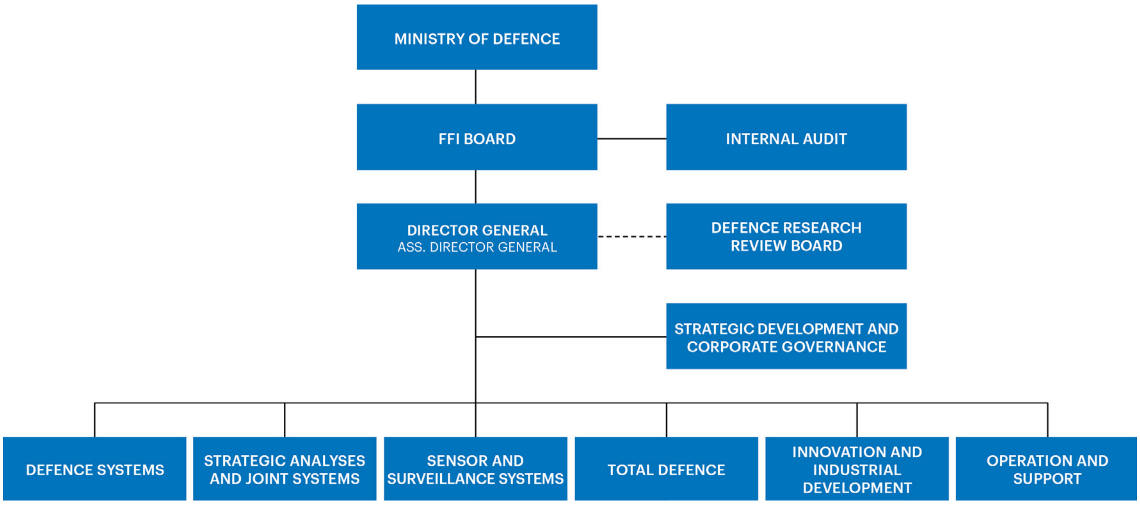

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